SN 10/824,691
Docket No. S-102,389
In Response to Office Action dated May 16, 2005

REMARKS

Claims 6-22 and 39-43 are pending in the present patent application. Claims 8, 9, and 17 have been withdrawn from consideration. Claims 6, 7, 10-16 and 18-22 are rejected.

Claims 6, 7, 10-16 and 18-22 are rejected under 35 U.S.C. 112, second paragraph.

With regard to the rejection under 35 U.S.C. 112, second paragraph, according to the present Office Action, claim 6, step (a) is not understood as to how "and/or" should be interpreted. Applicant has amended claim 1, part (a) by listing ball-milled products without and/or language.

Also with regard to the rejection under 35 U.S.C. 112, second paragraph, according to the present Office Action, ball-milling graphite does not convert graphite into amorphous material. Applicant respectfully disagrees. According to Huang et al, which was used in the present Office Action, ball-milling graphite produces amorphous material. FIGURE 1a of Huang et al. (see page 1179, col. 1) shows an XRD pattern of graphite and hexagonal boron nitride after 60 hours of ball milling. According to Huang et al., this XRD pattern "...shows two amorphous-like haloes featuring amorphous or turbostratic structures of the end product...". Huang et al. states specifically that this "... result also demonstrates that BM is an effective way to render crystalline graphite and h-BN to an amorphous-like structure, which is also consistent with our previous observation that an amorphous BN (a-BN) or an amorphous carbon (a-C) can be produced by the BM technique...". Furthermore, according to Huang et al., "...the amorphous or turbostratic nature of the milled $(BN)_{0.5}C_{0.5}$ is further confirmed by the HRTEM image shown in Fig. 2. In this figure, in addition to the amorphous phase, very small crystallites with only a few basal-plane spacing in thickness also exist, indicating that the end product is essentially a mixture of an amorphous and a nanocrystalline phase, with is also consistent with our previous results on a-BN and a-C...". Thus, according to Huang et al, ball milling a mixture of graphite and hexagonal boron nitride produces amorphous carbon.

Applicant has used x-ray diffraction to verify that amorphous carbon is a product of ball-milling a mixture of graphite and hexagonal boron nitride. FIGURE 2 of the

present patent application shows an x-ray diffraction pattern of powder before ball milling and an x-ray diffraction pattern of a ball-milled mixture. The upper spectrum of FIGURE 2 shows the x-ray diffraction pattern of hexagonal boron nitride and graphite before ball milling. This diffraction pattern indicates that the starting material is crystalline. The lower spectrum of FIGURE 2 is for the mixture after it has been ball milled for 34 hours, and indicates an amorphous composition.

Claim 18 was rejected under 35 U.S.C. 112, second paragraph, because there was not antecedent basis for "the amorphous mixture". Applicant has amended claim 18 by replacing "amorphous" with "ball-milled". With these changes and for the above reasons, Applicant respectfully requests that the rejection of claims 6, 7, 10-16 and 18-22 under 35 USC 112, second paragraph, be withdrawn.

Claim 6 has been rejected under 35 U.S.C. 102(b) over Huang et al. According to the Office Action, "...Applicant does what is disclosed in Huang et al. For example, see section II. Thus, the same results should be obtained...".

Applicant has amended claim 6 by amending the pressure range to a pressure of from about 15 GPa to about 25 GPa and to at least one temperature of from about 2000 K to about 2500 K. Applicant has also amended claim 6 by making it clear that the ball-milled mixture is encapsulated under pressure first and then the encapsulated, pressurized, ball-milled mixture is heated to form the bulk compact. Huang et al. does not operate within these parameters. Huang et al. uses a much lower pressure of 7.7 GPa. Applicant has also amended claim 6 to clarify that the product has at least one ternary B-C-N phase, i.e. a phase of the formula $B_xC_yN_z$ where x and y and z are each greater than zero. By contrast, Huang et al. combines graphite and h-BN, forms a ball-milled mixture, and then heats the mixture at elevated temperature and pressure but does **not** obtain Applicant's ternary phase-containing product. As Huang et al. states on page 1184, part IV (CONCLUSIONS), "...the a-BCN undergoes a phase separation under HPHT conditions of 7.7 GPa and 2300 °C. The resultant phases are c-BN, amorphous carbon, and turbostratic graphite. There are no mutual solubilities between c-BN and carbon, and the two different species (C and BN) are well separated. An epitaxial relationship, i.e., (0002) planes of graphite being parallel to (111) planes of c-BN was also found. *No ternary BCN phases were found in this experiment...*"

(emphasis added). For the above reasons, Applicant believes that amended claim 6 is allowable in view of Huang et al. and respectfully requests that the rejection of claim 6 under 35 U.S.C. 102(b) be withdrawn.

Claim 18 has been rejected under 35 U.S.C. 103(a) as being unpatentable over Huang et al. in view of Solozhenko et al "Synthesis of superhard cubic $BC_2N$. According to the present Office Action, "...Huang et al. does not disclose the use of the claimed capsule. It would have been obvious to use the Solozhenko rhenium capsule-depending upon what apparatus is readily available to produce the needed temperatures and pressures...".

Applicant has already shown that Huang does not produce a compact having a ternary B-C-N phase, and the use of a rhenium capsule under the Huang et al. conditions will not change that result. For this reason, Applicant believes that claim 18 is allowable over Huang et al. in view of Solozhenko and respectfully requests that the rejection of claim 18 under 35 U.S.C. 103(a) over Huang et al. in view of Solozhenko et al. be withdrawn.

Claims 6-7 and 10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Corrigan (U.S. Patent 4,289,503) in view of Kume (U.S. Patent 5,536,485 and/or Geyer (U.S. Patent 5,211,727). According to the Office Action, with regard to step (a) of claim 6, "...Corrigan discloses the use of hexagonal BN powder with a maximum dimension of 100 nm. Thus it is deemed that this discloses the limitation relating to "nano"...". Also, Corrigan discloses "...the use of graphite..." and that "...it would have been obvious to use graphite on the same size (or smaller) as the BN size, so that the graphite can be situated between the BN grains to prevent their fusion...". The Office Action notes that Corrigan does not disclose ball milling of the mixture. With regard to step (b) of claim 6, the Office Action states that Corrigan discloses the encapsulation. With regard to step (c), according to the present Office Action, Corrigan discloses "...sintering at 2273-2573, and 6.5-7.5 GPa (as the Examiner converts it)...". The Office Action then states that as to being superhard the BN portion of Corrigan's product is superhard compared to a pillow or a marshmallow. The Office Action then describes what it believes is a broadest reasonable interpretation of B-C-N as a composition of $B_xC_yN_z$ where x and y are 1 and z is zero. The Office Action then assumes that Corrigan

would get diamond like carbon grain boundaries because that is what Applicant got. Then, the Office Action concludes that it would have been obvious to use ball milling because Geyer and Kume provide evidence that it is well-known in the art to use ball-milling to disagglomerate material. With regard to claims 7 and 10, according to the present Office Action, it would have been obvious to use as much carbon as desired to prevent particles from fusing. With regard to claims 19-22, according to the present Office Action, the Corrigan compact would have areas of hardness that are the same as Applicant's because performing the same process as Applicant should result in the same product.

With regard to the hardness of superhard materials, Applicant has stated in column 1, lines 19-20 of the present patent application that superhard materials are materials having a Vickers hardness (i.e. an indention hardness) of at least 40 GPa). Applicant has amended claim 6 by limiting the pressure and temperature ranges to pressure in the range of from about 15 GPa to about 25 GPa, and temperature in the range of from about 2000 K to about 2500 K), and making it clear that the powder was encapsulated at a pressure within this range. These are the temperatures and pressures of dependent claim 11, now cancelled, which provide products having at least one ternary B-C-N phase. This pressure range is out of the range of Corrigan. Even if this range were in the Corrigan range, Corrigan does not teach a process for making ternary phase B-C-N. Instead, Corrigan provides a process for converting hexagonal boron nitride (HBN) to cubic boron nitride (CBN). In Corrigan, claim 1, part (iv), the process specifically calls for the absence of impurities that interfere with the conversion to cubic boron nitride. While Corrigan, col. 6, lines 4-5 mentions that graphite can be mixed with the hexagonal BN sample to prevent particle fusion, Corrigan does not teach or describe any product that includes carbon, let alone a product having a ternary phase of B-C-N. The Corrigan product is cubic BN. Furthermore, even if Corrigan used enough graphite to produce a product that included carbon, it is submitted that Corringan's conditions of pressure and temperature are very similar to those of Huang et al., and Huang et al. did not produce a ternary B-C-N phase but instead produced a phase segregated product of graphite and BN. Furthermore, Applicant has already shown that when h-BN and graphite are sintered within the claimed pressure and temperature

range of claim 6, the product would not have a ternary B-C-N phase unless the h-BN and graphite were subjected to ball-milling. The current specification demonstrates on page 12, lines 5-14 of the present patent, "...The effects of using a ball-milled amorphous material as the precursor material were examined by preparing compacts from a different precursor material: a mixture of graphite and hexagonal boron nitride (hBN) that had not been subjected to ball milling. Compacts prepared without ball milling the mixture of graphite and hBN did not include nanocrystalline grains of $BC_2N$. Instead, these compacts included *segregated phases of diamond and cBN*. The presence of segregated phases was first suggested by optical microscopy, more strongly indicated by x-ray diffraction spectra that showed twin-peaks of all the major x-ray diffraction peaks, and finally confirmed by Raman spectra that showed the characteristic peaks of diamond and cBN...". Thus, even if Corrigan or Kume provided the motivation to include a ball-milling step to Corrigan, the product would not have been Applicant's product. Importantly, with regard to such a combination, the mere statement that because ball milling is well known does **not** provide the necessary motivation for combining ball milling with the teachings of another patent. The motivation for such a combination must come from the references themselves, not from Applicant's own specification. For this particular invention, ball milling changed the structure of the ingredients from crystalline to amorphous. For the above reasons, Applicant submits that amended claim 6 is not obvious under 35 U.S.C. 103(a) over Corrigan in view of Kume and/or Geyer, and respectfully requests that the rejection under 35 U.S.C. 103(a) be withdrawn.

Claims 7 and 10, which relate to the composition of the ball-milled mixture, are dependent from amended claim 6. Applicant believes that claim 6 is allowable in view of the combination of Corrigan and Kume and/or Geyer and that claims 7 and 10 are also allowable and respectfully requests that these rejections under 103(a) be withdrawn.

Claims 19-22 relate to the hardness of the product formed according to the process of amended claim 6. Applicant believes that amended claim 6 is allowable in view of the combination of Corrigan and Kume and/or Geyer, and that claims 19-22 are also allowable in view of this combination, and respectfully requests that these rejections under 35 U.S.C. 103(a) be withdrawn.

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Claims 6-7, 10-16, and 19-22 are rejected under 35 U.S.C. 103(a) as being unpatentable over Adadurov (U.S. Patent Number 4,483,836 in view of Kume (U.S. Patent Number 5,536,485 and/or Geyer (U.S. Patent Number 5,211,727). According to the present Office Action, "...Adadurov discloses the invention as claimed, except for ball milling. Such would have been obvious in view of Kume and/or Geyer as discussed above. Example 33 of Adadurov discloses the use of graphite and boron nitride. Col. 4, lines 11-18 suggests the use of carbon down to sized 10 nm. Feature 1 is the capsule in which the material is encapsulated...". Also according to the present Office Action, "...claim 1 of Adadurov discloses that the temperature and pressure varies in a manner that for at least some time period the pressure value and the temperature value is met. As to the grain boundaries and other structural limitation of Applicants step c), it is deemed that since Adadurov and Applicant practice substantially the same process, that the substantially the same product would result. It is noted that: col. 5, lines 14-34 of Adadurov suggests that the mixture of carbon and BN can be in the form of granules. It is deemed that the granules would be transformed into bulk material. Claim 7: example 33 teaches equal parts by weight. Claim 10: col. 5, line 5 teaches using "various fractional compositions". It would have been obvious to use the 4:1 ratio-depending upon what final product is desired. Claims 11-16: are clearly met when using the above mentioned broadest reasonable interpretation because all of the pressures and temperature were achieved during the Adadurov explosion. Claims 19-22 it is deemed that the compacted granules would have areas of hardness that are the same as applicant, because performing the same process should result in the same product...". Applicant respectfully disagrees.

Applicant's present patent application relates to a method for preparing a compact by sintering a pressurized, encapsulated mixture of ball-milled powder, as claimed in Applicant's independent claim 6. The Adadurov patent, on the other hand, relates to a method for preparing a wide variety of products by detonating a shaped charge that largely composed of an explosive. Although detonation may involve the generation of high pressures and temperatures, detonation of Adadurov's shaped charge **is not sintering**. Sintering involves the production of a compact from a pre-sintered body (the encapsulated ball milled mixture). One pre-sintered body results in

one compact, and the compact usually has a shape similar to that of the pre-sintered body. Adadurov, on the other hand, begins with a shaped charge and detonates the charge inside a container to produce detonation products, and then collects the products. The detonation products are usually in the form of powder, and **never** a sintered compact. Example 33 of Adadurov, which the Office Action has particularly cited, describes detonating a tubular shaped charge of a mixture of 450 g of hexogen explosive, 75 g of graphite, and 75 grams of h-BN. Thus, more than 75 percent of the shaped charge is explosive, not graphite or boron nitride. After detonating the charge, solid detonation products that include diamond, diamond-like modifications of boron carbide, boron oxide, boron carbide, and detonator fragments are obtained. Thus, a wide variety of solid products are the result of the detonation, **not a sintered compact**. For this reason alone, the Adadurov method is different from Applicant's claimed method. Furthermore, Applicant's method involves forming a compact by first preparing a ball-milled product. As the Office Action noted, Adadurov does not ball mill. However, according to the Office Action, ball milling is a process commonly used for disagglomerating powder according to Kume and/or Geyer, and for this reason alone it would be obvious to combine ball milling with Adadurov. The mere fact that ball milling is a known process that could be performed on powder does not provide the necessary motivation to combine ball milling with the Adadurov process. The motivation for such a combination must come from the references. Such motivation is absent from the references. Even if such motivation were present, the additional ball-milling step would not provide Applicant's invention as claimed in claim 6 because the Adadurov detonation process is not sintering. In addition, Applicant's claimed compact includes at least one ternary phase of B-C-N. Nowhere does Adadurov mention that the conditions employed lead to such a phase. The explosive conditions described in Adadurov likely do not result in a ternary phase because the detonation likely does not put the boron and carbon into contact for a sufficient amount of time for the infiltration and chemical reaction required to produce a new phase. Furthermore, even if such a phase were present, the Adadurov method is still different from Applicant's because Adadurov does not sinter. For these reasons, Applicant submits that amended claim 6 is not obvious over Adadurov in view of Kume and/or Geyer and respectfully requests that the

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rejection under 35 U.S.C. 103(a) over Adadurov in view of Kume and/or Geyer be withdrawn.

According to the present Office Action, Applicant's Information Disclosure Statement filed on April 14, 2004, which included hardcopies of all of the non-patent references, is defective because Applicant did not provide the dates of publication for the non-patent documents. According to MPEP 609 (III), the month and year of publication are sufficient. Applicant wishes to point out that Taniguchi et al. was not considered even through both the month and year of publication were provided.

Applicant respectfully requests that this amendment be entered into the present patent application. For the reasons set forth above, Applicant believes that all currently pending claims are in condition for allowance, and such action at an early date is earnestly solicited. No new matter has been added. Reexamination and reconsideration are respectfully requested.

Respectfully submitted,

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